REMARKS

Claims 1-7, 11, 28-31 and 36-38 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Gormley, U.S. Patent 6,818,564 in view of Peeters et al., U.S. Patent 6,300,665. Claims 10-10, 12-27 and 32-35 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Gormley '564 in view Peeters et al. '665 and further in view of Flanders et al., U.S. Patent 6,341,039.

The Examiner's rejections are respectfully traversed.

It is respectfully submitted that the rejection of claim 1 is incorrectly made, and that claim 1 is novel and not obvious. None of the prior art references describe a method for forming a micro-mechanical component in a semiconductor wafer, which includes all the steps of claim 1, and furthermore, none of the prior art references, whether considered separately or combined, suggest such a method.

The invention is directed towards a method for forming a micro-mechanical component in a semiconductor wafer so that the risk of rupturing or deforming the micro-mechanical component or a part thereof is minimized. In particular, where the micro-mechanical component is a micro-mirror, the object of the invention is to prevent rupturing of the tethers which tiltably connect the micro-mirror to the membrane layer, and to prevent bowing of the micro-mirror. In the preferred embodiments of the invention, which are described in the specification, the micro-mechanical component is a micro-mirror 5, which is tiltably connected to the membrane layer 2 by two tethers 7. A communicating opening formed by a bore 9 extends through the handle layer 3 and the buried insulating layer 6 to expose the underside of the micro-mirror 5. Electrodes (not shown) which would be carried on another layer of silicon would generate appropriate electric fields, which would co-operate with the underside of the micro-mirror 5 through the communicating opening 9 for tilting the micro-mirror 5.

In prior art methods for forming micro-mirrors similar to the micro-mirrors 5, trenches, similar to the trenches 14 are initially formed in the membrane layer to the buried insulating layer, which would be similar to the buried insulating layer 6. The trenches would define the micro-mirrors, and would also define tethers similar to the tethers 7 for tiltably securing the micro-mirrors to the membrane layer. At this stage, portions of the buried insulating layer which bridge the trenches are exposed by the trenches. A bore similar to the bore 9 is then formed, initially through the handle layer, and then through the insulating layer. As discussed in the

specification from page 3, line 12 to page 4, line 27, in prior art methods during etching of the bore in the handle layer, significant stresses are induced in the buried insulating layer, and additionally, in many cases, thinning of the buried insulating layer occurs. These stresses, which are induced in the buried insulating layer, cause the insulating layer beneath the trenches to bow and curl, due to the fact that the insulating layer is unsupported on both sides beneath the trenches. The bowing and curling of the insulating layer leads to its rupturing from the remainder of the buried insulating layer which is located between the membrane layer and the handle layer. Since the tethers are of relatively small transverse cross-section, and furthermore, since the tethers are attached to the buried insulating layer, curling of the portions of the buried insulating layer beneath the trenches can cause the tethers to curl with the curling portions of the buried insulating layer, and this leads to rupturing of the tethers.

Additionally, as described in the specification from page 3, line 30 to page 4, line 5, even where stresses induced in the buried insulating layer resulting from etching of the bore in the handle layer in prior art methods do not lead to rupturing of the tethers, the induced stresses in the buried insulating layer can be sufficient to cause bowing of the buried insulating layer adjacent the micro-mirrors, which in turn results in bowing of the micro-mirrors.

In the method according to the invention, which is described with reference to the drawings, rupturing of the tethers 7 is avoided by providing the support layer 20 extending over the portions of the buried insulating layer 6 which bridge the trenches 14 before the bore 9 is etched in the handle layer 3. The support layer 20 thus supports the portions of the buried insulating layer 6 which bridge the trenches 14 when the other side of the buried insulating layer 6 is exposed by the bore 9. Furthermore, the support provided by the support layer 20 to the portions of the buried insulating layer 6 which bridge the trench 14 is sufficient to counteract the stresses induced in the buried insulating layer 6 during etching of the bore 9 in the handle layer 3, thereby preventing curling of the bridging portions of the buried insulating layer 6 beneath the trenches 14, and in turn rupturing of the bridging portions is avoided. By preventing curling and rupturing of the bridging portions of the buried insulating layer 6, curling and rupturing of the tethers 7 is in turn avoided. By providing the support layer 20 over the micro-mirror 5 as well as over the bridging portions of the buried insulating layer 6 beneath the trenches 14, the support layer 20 counteracts the stresses induced in the buried insulating layer 6 beneath the micro-

mirror 5 resulting from etching of the bore 9 in the handle layer 3 to the extent that bowing of the micro-mirror 5 is effectively eliminated.

Claim 1 recites a method for forming a micro-mechanical component in a semiconductor wafer comprising a membrane layer supported on a handle layer with a buried insulating layer disposed between the membrane layer and the handle layer, the micro-mechanical component being formed in the membrane layer, and a communicating opening extending through the handle layer and the buried insulating layer exposing the micro-mechanical component. The method of claim 1 recites the following steps:

(a) forming at least one trench extending through the membrane layer for defining the micro-mechanical component therein, each trench exposing a portion of the buried insulating layer bridging the trench, and

(b) applying a support layer to each bridging portion of the buried insulating layer, the support layer extending across each trench, and being applied to each bridging portion of the buried insulating layer **prior** (*emphasis added*) to the bridging portion being exposed by the communicating opening through the handle layer for supporting the bridging portion for preventing rupturing of the buried insulating layer when the buried insulating layer is exposed by the communicating opening through the handle layer.

None of the prior art references, taken alone or in combination, disclose or suggest a method for forming a micro-mechanical component in a semiconductor wafer which comprises the above two steps (a) and (b).

The Examiner contends that Gormley '564 discloses a method for forming a micro-mechanical component in a semiconductor wafer where a membrane layer supported on a handle layer with a buried insulating layer is disposed between the membrane layer and the handle layer. The Examiner further contends that the micro-mechanical component of Gormley is formed in the membrane layer, and a communicating bore extends through the handle layer and the buried insulating layer exposing the micro-mechanical component. The Examiner further contends that Gormley discloses forming at least one trench extending through the membrane layer for defining the micro-mechanical component therein, and that each trench exposes a portion of the buried insulating layer bridging the trench. Applicants do not dispute this, nor do the Applicants

dispute the Examiner's statement regarding the disclosure of Gormley in the first paragraph on page 3 of the official letter.

The Examiner contends that Peeters et al. '665 discloses a method for forming a micro-mechanical component in a semiconductor wafer where a membrane layer 1403 is supported on a handle layer with a buried insulating layer disposed between the membrane layer 1403 and the handle layer 1041. Applicants presume the reference numeral "1041" is quoted in error, and should in fact be the reference numeral "1401". The Examiner refers to Fig. 14b: column 10, lines 8 to 21 of Peeters. It is respectfully submitted that the Examiner's understanding of the layer in which the micro-mechanical component of Peeters, which is a micro-mirror 405, is formed is incorrect.

The layer in which the micro-mirror 405 of Peeters is formed is not assigned a reference numeral as such. Peeters uses the reference numeral 1401 as identifying both the handle layer and the membrane layer. The buried insulating layer of Peeters, which is located between the membrane layer and the handle layer, is referred to in his specification at column 10, lines 58 and 59 as a buried oxide layer 1475 and at column 10, line 66 and column 11, line 2 as a buried dielectric layer 1475. While illustrated in Figs. 14a to 141 the buried oxide/dielectric layer 1475 is not identified with the reference numeral 1475. However, for the assistance of the Examiner, copies of Figs. 14a to 141 are enclosed with the buried dielectric layer of Peeters identified with the reference numeral 1475. The layer which the Examiner has referred to as being a membrane layer 1403 in Peeters is in fact a dielectric layer, see column 10, lines 12 to 15, where it is stated "Fig. 14a shows silicon on insulator substrate 1401 with dielectric, typically, Si_3N_4, layers 1402 and 1403 deposited on two sides of silicon on insulator substrate 1401".

The Examiner then contends that the micro-mechanical component 405 of Peeters is formed in the membrane layer 1401, which the Applicants would not dispute, and that a communicating opening 1450 extends through the handle layer 1401 and the buried insulating layer exposing the micro-mechanical component 405, which Applicants would likewise not dispute. However, the Examiner then contends that Peeters' method requires "forming at least one opening extending for defining the micro-mechanical component 405 therein".

This statement of the Examiner appears to have a word missing, since the Examiner does not indicate from where or to what or through what the "opening" which is allegedly "extending" extends. The opening which Peeters forms which defines the micro-mirror 405 in the membrane

layer is an opening which is formed in the step illustrated in Fig. 14k using the mask 707 illustrated in Fig. 7g after the communicating opening 1450 has been formed.

The Examiner then states "each opening exposing a portion of the membrane layer 1401 bridging the openings". It is respectfully submitted that the Examiner at this stage appears to have failed to understand the method of Peeters. The forming of the opening which is formed by the mask 707 of Fig. 7g to define the micro-mirror 405 requires that the buried insulating layer 1475 is etched first before the opening, since the opening which defines the micro-mirror 405 is etched from the communicating opening 1450 and therefore in order to commence etching of the opening in the membrane layer to define the micro-mirror 5, the buried insulating layer 1475 must first be etched. Thus, when the opening which defines the micro-mirror 405 has been etched through the membrane layer, there is no portion of the buried insulating layer, or the membrane layer bridging the opening, since the opening is actually formed first through the buried insulating layer 1475 and then through the membrane layer.

The Examiner then states that Peeters requires the step of "applying a support layer 1408 to each bridging portion", and the Examiner refers to Figs. 14f, column 10, lines 21 to 35. The layer 1408 is a sputter deposited layer of MoCr, and has no supporting function whatsoever with respect to the buried insulating layer 1475. The layer 1408 is provided to form tethers or suspension arms 450 for suspending the micro-mirror 405 from the membrane layer. The Examiner is respectfully referred to Fig. 15.

The Examiner further contends that the alleged support layer 1408 extends across each opening and is applied to each bridging portion prior to the bridging portion being exposed by the communicating opening 1450 through the handle layer 1401 for supporting the bridging portion for preventing rupturing of the buried insulating layer when the buried insulating layer is exposed by the communicating opening through the handle layer. Applicants are at a loss to understand the relevance of this passage, which appears at the end of page 3 of the official letter.

It is respectfully submitted that the Examiner has confused the various layers of Peeters and their function, and the sequence in which the opening which defines the micro-mirror 405 and the communicating opening 1450 are formed.

Briefly, the micro-mirror 405 of Peeters is formed in the membrane layer of Peeters, which is the layer immediately above the buried insulating layer 1475 of the silicon on insulator substrate (SOI) 1401. The micro-mirror 405 is coupled to the membrane layer by suspension

arms 450, see Figs. 15 and 12. Initially, as illustrated and described with reference to Figs. 14a to 14h, Peeters constructs the suspension arms 450 which are to suspend the mirror 405 in the membrane layer. On completion of the construction of the suspension arms 405, Peeters then forms a photoresist layer 713 on the dielectric layer 1402 on the bottom of the SOI 1401, which is patterned to define the communicating opening 1450. The communicating opening 1450 is then etched in the SOI 1401 to the buried insulating layer 1475, which acts as an etch stop layer, see Fig. 14j. After etching of the communicating opening 1450 has been completed, the remaining portion of the dielectric layer 1402 and the exposed portion of the buried dielectric layer 1475 are coated with the photoresist mask 707 of Fig. 7g and patterned. The exposed side walls in the communicating opening 1450 are also coated with a photoresist layer 1451. See Fig. 14k and column 10, lines 60 to 64. The exposed areas are then deep reactive ion etched to remove the exposed portion of the buried dielectric layer 1475 as well as the portions of silicon on insulator substrate 1401, which forms the opening in the membrane layer which defines the micro-mirror 405. These are the openings which we have identified with the reference letter A in the attached copy of Figs. 14k and 14l of Peeters. This etch is continued for etching the dielectric layer 1403 and the dielectric layer 1406 as shown in Fig. 14k. Thus, at no time is the buried insulating layer 1475 of Peeters left to bridge an opening or a trench in the membrane layer which defines the micro-mirror 405, since the buried insulating layer 1475 must be etched prior to etching the opening or trench in the membrane layer which defines the micro-mirror 405.

While Peeters discloses forming openings or trenches in a membrane layer to define a micro-mirror 405, it is therefore respectfully submitted that Peeters fails to disclose feature (a) of the method of claim 1, since none of the openings or trenches formed in the membrane layer to define the micro-mirrors 405 expose a portion of the buried dielectric layer 1475. Furthermore, and of most importance, Peeters entirely fails to disclose feature (b) of claim 1. Additionally, it is respectfully submitted that there is no suggestion in the disclosure of Peeters of a method for forming a micro-mechanical component in a semiconductor wafer which comprises steps (a) and (b) of the method of claim 1.

Flanders et al. '039 describes a tunable Fabry-Perot filter which includes an optical cavity and a micro-mirror 34 formed in a silicon on insulator. Flanders describes three methods for fabricating the filter with reference to Figs. 4A to 4I, 5A to 5G and 7A to 7G. However, nowhere in the specification of Flanders is there a disclosure or a suggestion of a method for

forming a micro-mechanical component in a semiconductor substrate which comprises the step of feature (b) of claim 1.

Accordingly, since as accepted by the Examiner, Gormley '564 fails to disclose the step of feature (b) of the method of claim 1, and since Peeters fails to disclose the steps of both features (a) and (b) of claim 1, and since there is absolutely no disclosure in the specification of Flanders of the step of feature (b), it is respectfully submitted that the invention of claim 1 is novel.

Furthermore, it is respectfully submitted that Gormley fails to suggest a method for forming a micro-mechanical component in a semiconductor wafer which includes the step of feature (b), and furthermore, as discussed above, there is no disclosure or suggestion of the possibility of providing the step of feature (b) in the methods of Peeters and Flanders, it is therefore respectfully submitted that whether Gormley, Peeters or Flanders are considered separately or combined, the invention of claim 1 is not obvious. Accordingly, it is respectfully submitted that the invention of claim 1 should be allowable and allowance is respectfully requested.

Since claims 2 to 35 are dependent either directly or indirectly on claim 1, it is respectfully submitted that once the Examiner is satisfied of the allowability of claim 1, claims 2 to 35 should likewise be allowable. Claim 36 is directed towards a method for forming a semiconductor wafer which is formed according to the method of claim 1, and accordingly, it is respectfully submitted that once the Examiner is satisfied of the allowability of claim 1, claim 36 should likewise be allowable.

Claim 37 is dependent on claim 36, and it is respectfully submitted that once the Examiner is satisfied of the allowability of claim 36, claim 37 should likewise be allowable.

Claim 38 is directed towards a semiconductor wafer which comprises features which essentially correspond to the features claimed in the method of claim 1, and it is respectfully submitted that once the Examiner is satisfied of the allowability of claim 1, claim 38 should likewise be allowable.

In view of the foregoing, it is believed that the amended claims and the claims dependent there from are in proper form. Applicants respectfully contend that the teachings of Gormley '564 in view of Peeters et al. '665 and further in view of Flanders et al. '039 do not establish a

prima facie case of obviousness under the provisions of 35 U.S.C. §103(a). Thus, claims 1-38 are considered to be patently distinguishable over the prior art of record.

The application is now considered to be in condition for allowance, and an early indication of same is earnestly solicited.

Respectfully submitted,

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